Hydrogeochemical Baseline Mapping of the Great Artesian Basin Groundwater

Authors: Tehani Kuske[1], Simon van der Wielen[2], Richard Dunsmore[1], Tim R. Ransley[3], John Draper[4] and Andrew J. Feitz[1]

Affiliation: [1]Greenhouse Gas Monitoring, Geoscience Australia; [2]Onshore Energy and Minerals Division, Geoscience Australia; [3]Groundwater Group, Geoscience Australia; [4]Geological Survey of Queensland, Department of Employment, Economic Development and Innovation

The first large-scale projects for geological storage of carbon dioxide (CO_2) on the Australian mainland are likely to occur within sedimentary sequences that underlie or are within the Triassic-Cretaceous Great Artesian Basin (GAB) aquifer sequence. Recent national[1] and state[2] assessments have concluded that certain deep formations within the GAB show considerable geological suitability for the storage of greenhouse gases. These same formations contain trapped methane and naturally generated CO_2 stored for millions of years. In July 2010, the Queensland Government released exploration permits for Greenhouse Gas Storage in the Surat, Bowen and Galilee basins (Figure 1).

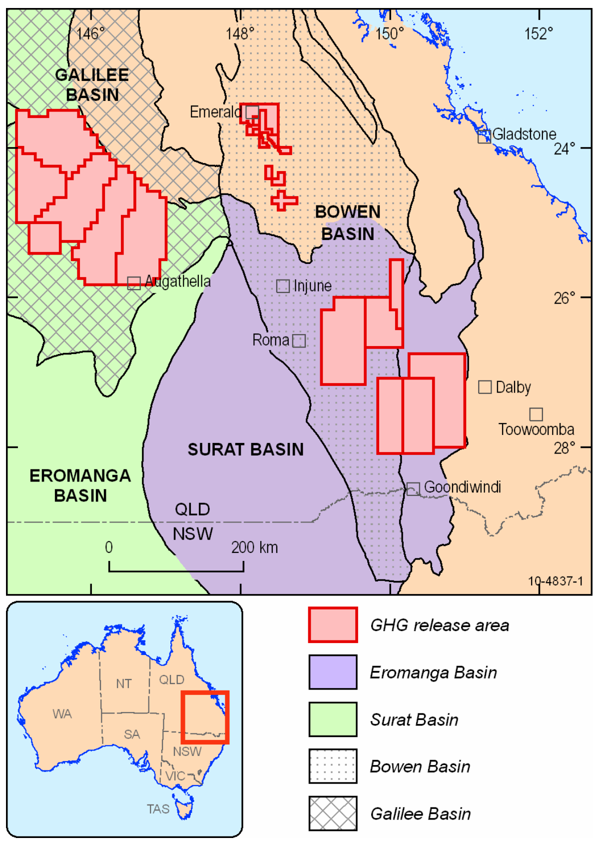


Figure. 1. Onshore areas released for GHG storage exploration in central Queensland

An important consideration in assessing the potential economic, environmental, health and safety risks of such projects is the potential impact CO_2 migrating out of storage reservoirs could have on overlying groundwater resources. The risk and impact of CO_2 migrating from a greenhouse gas storage reservoir into groundwater cannot be objectively assessed without an adequate knowledge of the natural baseline characteristics of the groundwater within these systems. Due to the phase behaviour of CO_2, geological storage of carbon dioxide in the supercritical state requires depths greater than 800m, but there are few hydrogeochemical studies of these deeper aquifers in the prospective storage areas.

Historical hydrogeochemical data were compiled from various State, Territory and Federal Government agencies. In addition, hydrogeochemical information has been compiled from thousands of petroleum well completion reports in order to obtain more information on the deeper aquifers, not typically used for agriculture or human consumption. The data were passed through a QC procedure to check for mud contamination and ascertain whether a representative sample had been collected. The large majority of the samples proved to be contaminated but a small selection passed the QC criteria. The full dataset is available for download from Geoscience Australia's Virtual DataRoom (vdr.ga.gov.au).

A 3D geological model of the GAB provided the framework for the hydrogeochemical mapping. Relevant datasets for the construction of the 3D geological map were imported into GoCad™. A series of 3D triangulated mesh surfaces were built for the major aquifer and aquitard units for the GAB using drill markers, surface geological mapping and seismic data. The surfaces were used to produce a geological voxet (3D block model) that was then populated with hydrochemical and geophysical wire-line logging data. The model of the GAB is designed so that it can be used for multiple applications including groundwater resource management, geological storage of greenhouse gas studies, and geothermal exploration. Only the total depth or screened depths of groundwater wells are available in many instances. In such cases, the well data is allocated to its respective formation using its location and depth within the 3D geological model.

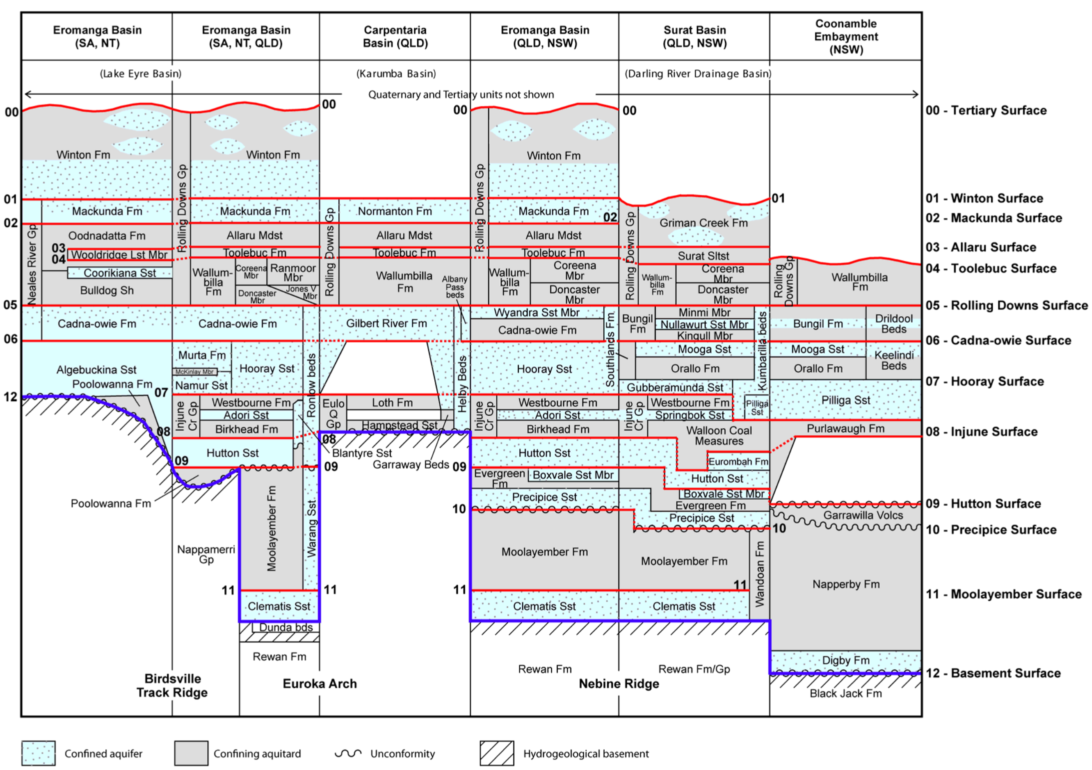
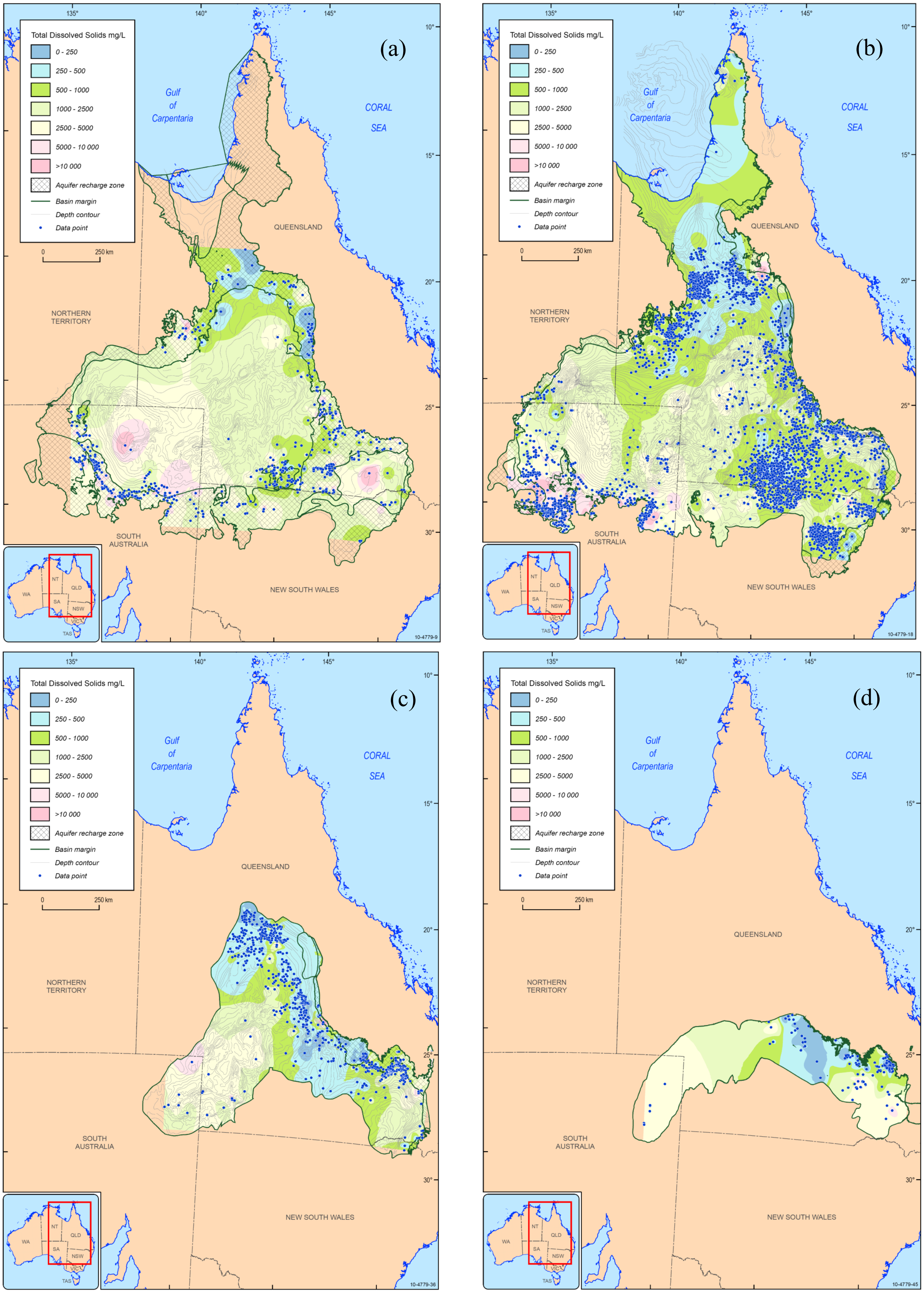


Figure 2. A time-space plot showing the correlation between the Eromanga, Surat and Carpentaria Basins. Main sandstone aquifers and confining aquitards for the Great Artesian basins are marked. The bold lines and text represent geological surfaces in the 3D map (adapted from Radke et al., 2000).



(a)
(b)
(c)
(d)
Total Dissolved Solids mg/L
0 - 250
250 - 500
500 - 1000
1000 - 2500
2500 - 5000
5000 - 10 000
>10 000
Aquifer recharge zone
Basin margin
Depth contour
Data point
0
250 km
135°
140°
145°
10°
15°
20°
25°
30°
Gulf of Carpentaria
CORAL SEA
QUEENSLAND
NORTHERN TERRITORY
SOUTH AUSTRALIA
NEW SOUTH WALES
WA
NT
QLD
SA
NSW
VIC
TAS
10-4779-9
10-4779-18
10-4779-36
10-4779-45

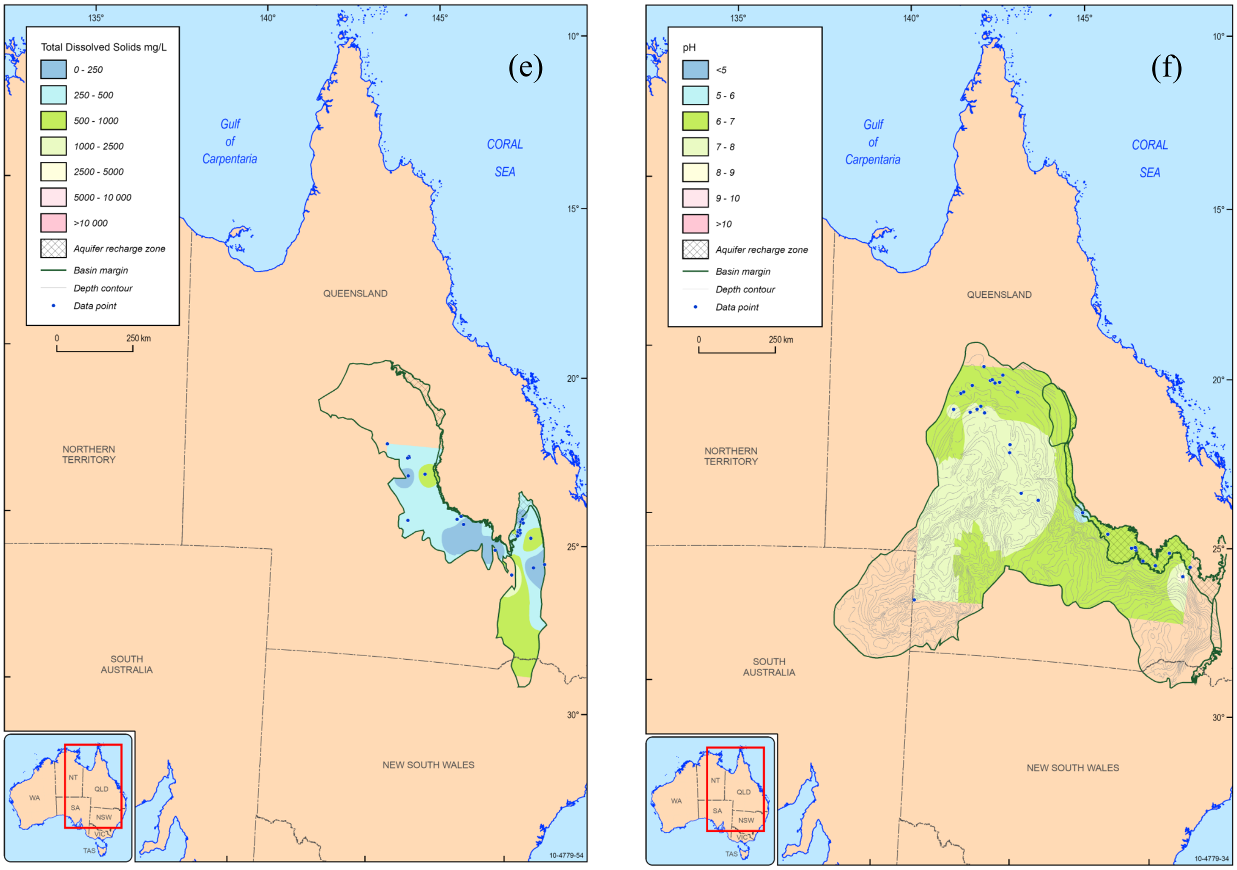


Figure 3. Total dissolved solids concentration for groundwater from the (a) Wallumbilla Formation/Rolling Downs Group; (b) Cadna-owie – Hooray Aquifer; (c) Hutton Formation; (d) Precipice-Poolowanna Formation and (e) Clematis Formation. Limited field pH data for Hutton Formation groundwater shown in (f). Source: Compilation of data from Geoscience Australia-GSQ groundwater surveys and data kindly supplied by Federal, State and Territory government agencies.

The point data sources were interpolated and extrapolated using ArcGIS tools to develop hydrogeochemical maps for the individual hydrological units. In the Surat Basin for example, there is reasonable regional data coverage for the Cadna-owie - Hooray and northern Hutton Sandstone aquifers, but data coverage is poor for the deeper Precipice Sandstone and Clematis Group aquifers. Measurements of field pH and Eh are under-represented and baseline data coverage for trace metals of possible concern (e.g. lead, nickel and arsenic) is particularly poor for all aquifers. The salinity of the groundwater is mostly fresh tending to brackish. The hydrogeochemcial maps developed as part of this investigation will assist industry and government in assessing the hydrogeological units for their potential use as greenhouse gas storage reservoirs, identify locations and aquifers where additional water chemistry data is urgently required, as well as providing a regional groundwater chemistry baseline.

1. Carbon Storage Taskforce (2009) National Carbon Mapping and Infrastructure Plan - Australia: Concise report, Department of Energy Resources and Tourism, Canberra.
2. Greenhouse Gas Storage Solutions (2009) Queensland Carbon Dioxide Geological Storage Atlas, compiled on behalf of Queensland Government Department of Employment, Economic Development and Innovation.
3. Radke B.M., Ferguson, J., Cresswell, R.G., Ransley, T.R. and Habernehl, M.R. (2000) Hydrogeochemistry and implied hydrodynamics of the Cadna-owie – Hooray Aquifer Great Artesian Basin, Bureau of Rural Sciences, Canberra.